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ABSTRACT

In both developed and developing countries a gap exists between universities and industry. In developed and industrialized countries universities are in the process of forsaking their ivory towers and forging strong links with industry, mainly through sponsored research and continuing education. In developing countries the gap is very wide indeed. How can it be bridged? This paper analyzes the university-industry gap syndrome and suggests means by which the gap can be reduced. Since research plays a very important role in promoting university-industry ties, the role of R&D as a linkage between universities and industry is also discussed. (Author)

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The University-Industry Gap and its Effect on Research and Development in Developing Countries

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In both developed and developing countries a gap exists between universities and industry. In developed and industrialized countries universities are in the process of forsaking their ivory towers and forging strong links with industry, mainly through sponsored research and continuing education. In developing countries the gap is very wide indeed. How can it be bridged? This paper analyses the university-industry gap syndrome and suggests means by which the gap can be reduced. Since research plays a very important role in promoting university - industry ties, the role of R&D as a linkage between universities and industry is also discussed.

The University - Industry Gap

The majority of countries that are today referred to as developing or third world countries were, in the not too distant past, the colonies or protectorates of colonial powers and as such their educational systems were modeled after those of the 'parent' countries. However, the educational systems of these parent countries were based essentially on the particular socio-cultural characteristics and historical evolution of each country rather than on actual industrial requirements (universities preceded industry by several centuries). This has led , over the years, to the establishment of a widening gap between universities and industry. The developed and highly industrialized countries realized (albeit fairly recently) that if this gap is not narrowed and bridged , the result would be detrimental to both sides and hence to the nation as a whole.

Perhaps the first country to realize the importance of bridging the gap and successfully do so is the United States, more than three decades ago. This is primarily due to its free-market-economy based industry and its non-centralized higher education system. In Europe and the UK serious efforts to establish closer links between industry and academe are much more recent - a little over a decade ago. In developing countries on the other hand, the 'alien' education systems coupled with the very large inertia inherent in any education system, has reduced these systems to a state of quasi-static lethargy. In spite of the growth of industry the universities have remained confined in their ivory towers with unfortunately little or no effort made to bridge the ever-widening university - industry gap. There are several reasons for this:

• Faculty staff have completed their college education, undergraduate or graduate or both, at universities in advanced countries. For reasons of prestige and recognition, curricula are modeled after those at such universities without any regard for local requirements. Liaison with any existing industries is completely ignored, since their requirements are considered to be well below the capabilities of universities: a question of who sets the standards, almost a matter of honor!

• In developing countries, industry in its infancy — public utilities and corporations as well as service industries — look up in awe at engineering colleges and are under the delusion that the graduating engineers will be capable of solving all their problems.

• In some developing countries, where graduates are 'assigned' permanent jobs, the bureaucracy of the socio-political system is such as to make it almost impossible to establish any meaningful ties between universities and industry.

• With very heavy teaching loads and promotion-oriented research work, faculty staff find very little time for promoting any of the university-industry interaction which is necessary for broadening professional experience and exposure.

In order to have a better perception of the university-industry gap syndrome, we have listed in Table 1 the principal factors contributing to this gap and in Table 2 the reasons why the gap needs to be bridged. The left hand side of each table lists the factors from the university point of view and the right hand side lists those from the point of view of industry.

To narrow the university-industry gap it is necessary that industry should:

• Carry out a needs analysis: where is it going and what are the human resources it needs to get there.
• Provide support for student projects.
• Sponsor long-term research.
• Hold periodic seminars in collaboration with universities.
• Provide support for and participate in continuing education programs in specific areas.
• Encourage consulting.
• Share equipment and facilities with universities.

The rate of scientific and technical information growth almost doubles every three to four years so that both managers and engineers will have to work with rapidly changing technologies. A university

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engineering education cannot provide undergraduates, in some 130-140 credit hours, with the knowledge which will serve them throughout their careers. Universities can provide them with basics and industry must allow and encourage them to participate in continuing education programs-today a lifelong learning process.

Industries which, due to scarce cash resources, cannot themselves organize continuing education programs, will benefit greatly by investing primarily in such programs offered by universities. The programs are a good source of income for the universities but their development requires close cooperation with industry.

From their side universities should:

• Recognize that the needs of industry have changed considerably and undertake to provide the quality of education that it requires. Today knowledge of technology alone is not sufficient: in addition to the formal engineering skills, industry requires people with communication skills and with knowledge of how technology relates to economics and the commercial world.

• Invite industry to participate in the planning and periodic reviewing of curricula and course contents at both the undergraduate and graduate levels.

Perhaps the most important single factor which contributes to a strong and lasting bond between industry and university is the field of research and development.

Research and Development as a Linkage between Industry and Universities

Today the two words *Research* and *Development* are inextricably linked together. This has not been always so.

Table 1. Factors Contributing to the University-Industry Gap

University Point of View	Industry Point of View
- Academic institutions are "non-profit" institutions which exist primarily to teach and educate students and undertake pure and fundamental research.	- Industry's almost sole objective is to make a profit by producing a marketable product or rendering a useful service.
- Academic research is an open activity where staff are valued by their publication record: their research is motivated by promotion and tenure and hence require maximum publicity. The motto for survival is "publish or perish".	- To safeguard investment, research is a closed activity and new developments require protection mainly through patents. Thus communication and publication are restricted. You publish only when competitors learn little from the discovery.
- Research is mainly to look for and extend new knowledge in an absolute way. Acquisition of knowledge itself is valuable.	- Knowledge is valuable only if it can be exploited in products. Likewise research is pointless unless investment in it can be justified by turning discoveries into products. R&D is a form of industrial investment leading to wealth creation.
- For faculty and staff research is a part time activity.	- In an industrial research laboratory research is a full time activity.
- There is no emphasis on urgency : research workers are more relaxed and more scholarly.	- Industry's goals are usually short-term. In technological development the overriding consideration is time.
- The main objective of university education is to develop the students' self-confidence, mental capacities and latent capabilities to produce creative individuals capable of independent thinking and mature judgment. It is not the function of universities to give professional training.	-University faculty lack industrial experience. There is thus a mismatch between industry's expectations and the type of education provided by the university. - University faculty tend to be patronizing.

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Table 2. Why the Gap Needs to be Bridged

University Point of View	Industry Point of View
- An urgent need for financial support particularly where government support is not forthcoming.	- Industry is the most direct beneficiary of engineering programs. Over 90% of graduates are ultimately employed by industry and by government or private utilities. This calls for the strengthening of ties with universities.
- Make use of sophisticated and expensive industrial equipment and facilities.	
- Industry can provide valuable cooperation and guidance for courses and student projects which are relevant to industry e.g. design and implementation of technology.	- Any company's most important asset is its staff. Engineers and scientists must be kept abreast of the rapid advances in science and technology and the best way of doing this is through sponsoring their staff for continuing education or professional advancement courses.
- Liaison with industry provides an excellent opportunity for faculty to acquire some first-hand industrial experience.	
- Liaison with industry can help identify problems that can either develop into sponsored research projects, joint projects or consulting opportunities.	- Utilize university talent and facilities at a maximum benefit to cost ratio. Thus consulting is an excellent way for faculty to have a close relationship with industry.
- Attract graduates from industry and government by developing a strong continuing education program which is practically oriented (Diploma courses) and in which experts from industry and government can cooperate with faculty and staff in specific topics.	- Universities are best suited to carry out long-term research on problems which require a high degree of sophisticated theoretical knowledge in specific fields.
	- Interaction with universities provides industry with a window into leading-edge scientific research.

In the past Research was the 'monopoly' of universities, whilst Development was the 'monopoly' of industries. Research implied 'pure' or 'disinterested' research almost totally dedicated towards finding out how nature works; its objective was to serve world science irrespective of economical and industrial considerations. Development on the other hand implied the improvement of existing technologies.

However, as a consequence of the staggering rate of advance of both science and technology, research became very detailed, specialized and expensive. Progress was accompanied by a continuous dissociation into particular problems resulting in the 'pulverization' of research – scientists knew more and more about less and less. This has led to the urgent need for persons with the specialized ability for integration and for making use of this integrated scientific knowledge in practical applications. When science is so used for practical purposes it normally becomes a technology and as such requires development. It was thus imperative that scientific research and technological development join forces to achieve the goals of wealth creation (building industries, creating employment, increase exports etc.) and improvement in the quality of life.

Taking a wide-angle view of research it is possible to define four categories of research:

–*Undirected research*: this is the so-called pure or disinterested or "blue sky" research. It is research pursuing exciting new and speculative ideas in which no immediate pay-off is perceived.

–*Fundamental research*: this is research directed towards identified gaps in knowledge. It is a major component of the type of research that industry looks to universities to perform.

–*Directed or strategic research*: this is research having a direct bearing on local conditions and long-range aims connected with economic and/or industrial potential of the country.

–*Applied or ad hoc research*: this is multidisciplinary research. It seeks solutions of identified industrial problems which use the already known facts of science. It is thus strongly associated with the development of technology and usually involves meeting the timescales needed for product development.

What is the position of developing countries vis-a-vis research and development as a linkage between

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industry and university? It would appear that any link between the two hardly exists.

Whereas in advanced countries universities have forsaken their ivory towers and are working with industry and government as partners in the research and development drive, in developing countries the universities still exist in "splendid isolation" as far as links with industry are concerned. There are several reasons for this:

-Lack of funds.
-Lack of any industrial experience, and hence awareness, amongst academics results in failure to direct engineering research towards industrial applications.
-Choice of research topics is made almost exclusively by the different supervisors, each according to his own inclination.
-The main objective and incentive for the research is to obtain promotion via publications.
-Research laboratories and support facilities are virtually non-existent or have been allowed to age without renewal.
-Lack of equipment and facilities has forced research work to be almost totally computer generated. Some of it could be termed "virtual research"!

In spite of this there is some excellent research work being done in developing countries. The problem is that either this research does not meet industry's needs or industry is unaware of its existence; also universities and research centers are not good at 'marketing' their products. In developing countries many universities have overcome this point by developing their own Technology Transfer Centers.

The low efficacy of research and development programs in developing countries is mainly due to the lack of a national R&D policy either in the public or private sectors of industry. Moreover, the all-important interface between industry and university is non-existent.

For universities to participate in and make positive contributions to research and development programs there has to be an effective industrial/academic interface such as the federal agencies in the US (NASA, DOD, AEC, HEW), the Universities Grant Commission and SERC (Scientific and Engineering Research Council) in the UK, the CNRS in France etc. Such an interface would be specialized agency acting as intermediary between government, industry and university. Government interest in research would certainly be of the directed or strategic type e.g. environmental issues, public health, defense requirements etc. Industry's interests are mainly in applied research whilst the traditional forte of universities is in fundamental and undirected research. Both government and industry should submit their problems and research needs to the agency which will then choose the most suitable place where the research can best be carried out: research center or university, and if there are several which one of them. To be effective the agency must be competent to make the right choice of research workers (a comprehensive and continuously up-dated national specialization-based 'who's who' in science and technology is a must), efficient in the follow-ups but most important for ultimate success is proper coordination. Government and industry must be prepared to provide the necessary funds for their projects via the specialized agency. Universities will submit their own research proposals directly to the agency. They may very well match existing industry needs; if not alternatives can be negotiated but the eternal problem of funding will inevitably raise its hoary head.

In order to ensure a cross-flow between industrial and academic communities, it is important that both industrialists and academics be equally represented in research council committees.

The establishment of specialized national research centers can also serve as very valuable links between universities and industry. In developing countries most of their future growth will come from the small and medium-sized industries, and it is these industries that stand to gain the most from such research centers. Research centers would:

- Make available to industry (and thus avoid duplication) expensive research equipment and test facilities.
- Have available highly qualified personnel with exceptional skills and a high degree of expertise in their fields of activity.
- Realize considerable savings in time and money by providing solutions to technological problems which may be common to several industries.
- Collaborate as partners with universities pursuing strategic research.
- Develop highly qualified human resources in their fields of activity.
- Act as centers for the transfer of technology.

It is a fact that most developing countries have immense socio-economic problems which makes them consider that any expenditure on research and development is a luxury. On the other hand the rich developing countries, which have abundant sources of natural wealth, do not feel either the urgency or the necessity for wealth generation so that R&D is given a very low priority. However all developing countries must realize that any R&D program, however modest, will provide excellent returns if effectively orientated and efficiently administered. They have to draw up their own model, one that is adapted to their own needs and particularities. By identifying suitable areas, limited resources could be harnessed to better effect. Of the many questions which they will have to answer the following are perhaps the most important:

- What is the size of commitment to research?
- What is the size of commitment to development?
- Which sciences and technologies should they concentrate on?
- Will they duplicate the work of others?

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- How can their research and technology capabilities be best transmitted into wealth-creating business activities?

There can be no doubt that science without industry (technology) will not lead to wealth creation or improve the quality of life, nor will industry without continuous research and development. Thus government, industry and university must all be convinced that a close partnership between them is vital in today's world of ferocious competitiveness. The question of course is who within these organizations must be convinced and how can such convincing best be done- through professional institutions perhaps? The answer is beyond the scope of this paper but is certainly a topic for discussion. However it is industry and its investors that must ultimately shoulder the burden of wealth creation. Without research and development the long term effect would be wealth depletion.

Summary

A narrowing of the university/industry gap in developing countries can be achieved :

(a) On the university side by:

- revising course curricula and degree plans to meet the various requirements of the different industries.
- inviting industry to participate in the planning and reviewing of undergraduate and graduate curricula.
- encouraging academic staff to carry out consulting work and cooperate with industry via the university and not via private offices.
- reducing its "time constant" by responding more quickly to changes.
- improving the experimental capabilities of university graduates through better laboratory training.

(b) On the industry side by:

- sponsoring staff for continuing education or professional advancement courses.
- funding research projects in areas of common interest.
- encouraging cooperation between university and industry through joint projects or consulting opportunities.
- sponsoring undergraduate design projects.
- assisting universities in updating laboratories and equipment

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